Attachment 1
Hydrodynamic and Sediment Transport Sampling Plan for 2004-2005

Lower Passaic River Restoration Project

Hydrodynamic and Sediment Transport Sampling Plan for 2004-2005

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Section 1
Introduction

1.1 Purpose

The purpose of this plan is to describe the 2004-2005 hydrodynamic sampling that will be conducted in the Lower Passaic River and provide guidance for the proposed field work through detailed descriptions of the sampling and data gathering methods. Initially, hydrodynamic sampling that focuses on the Harrison Reach was proposed by Rutgers University and the U.S. Geological Survey (USGS) to aid the N.J. Department of Transportation - Office of Maritime Research (NJDOT-OMR) in the implementation of a pilot dredge study planned by NJDOT-OMR for 2005. According to the Rutgers and USGS 2004 proposal, Characterizing the circulation and dispersive nature of the Passaic River and its dependence on river discharge and tidal range: elucidation of major processes that determine the impact of the proposed Passaic River dredging project, the purpose of NJDOT-OMR's investigation is to "characterize the aspects of the circulation and dispersive nature of the Passaic and describe how these processes change with tidal range and river discharge."

This same type of information is also needed by the Superfund project team, led by the U.S. Environmental Protection Agency (USEPA) Region 2, for the entire 17-mile tidal stretch of the Lower Passaic River. Therefore, two studies that complement each other, one through NJDOT-OMR and the other through the Superfund project team are proposed. This document discusses the data to be collected through both studies and provides details on the Superfund sampling.

1.2 Objective

One of the primary objectives for the Lower Passaic River Remedial Investigation and Feasibility Study (RI/FS) is to develop and apply a scientifically-based model that specifically incorporates hydrodynamic transport, sediment transport, contaminant fate and transport and bioaccumulation processes. This model will be used as a tool for understanding historical and current sources and sinks of organic and inorganic contaminants in the Passaic River and adjacent water bodies through mass balance analyses, as well as provide the basis for an engineering evaluation of potential remedial scenarios. To support this objective, it is necessary to monitor the river under both long-term and specific short-term (*e.g.*, during high-flow storm events) conditions to provide the data for model calibration and for comparison with the model predictions so that model performance can be made representative of the actual system conditions. This will allow the model to be used to simulate alternative scenarios within the system under both existing and hypothetical future conditions.

Large modeling projects require extensive parameter estimation as well as extension and extrapolation of the available data. This hydrodynamic and sediment transport monitoring program is intended to collect key data required to support the modeling effort. While some of the data collected will provide information on the long-term time series of hydrodynamic and suspended sediment concentrations, other data, like those obtained from experimental and field efforts on sediments deposition and erosion characteristics, will be used primarily for calibration of sediment parameters. In general, the greater the number of monitored locations and the frequency of data collection, the more closely the model can be made to replicate actual measured conditions.

To meet these objectives, the proposed hydrodynamic sampling program will:

- Objective 1 - Provide a baseline data set within the estuary for calibrating and assessing the skill of the hydrodynamic components of the proposed Lower Passaic River Model.
- Objective 2 - Determine sediment erosion and settling/flocculation to characterize model parameters.
- Objective 3 - Provide baseline data for characterizing the discharge and loads of suspended solids over the Dundee Dam, a boundary condition for the Lower Passaic River Model.

- Objective 4 - Provide current bathymetric survey data to further characterize sediment mobility, aid in future sediment sampling and risk assessment investigation and provide a dataset for comparison to previous surveys.
- Objective 5 - Determine the processes controlling the short-term fate and transport of particles[1] within the estuary, especially at the estuarine turbidity maximum (ETM).
- Objective 6 - Determine the variability in total suspended solids (TSS), particulate organic carbon (POC), and grain size, under varying tidal conditions, upstream river discharge, and stratification.

1.3 Sampling Scope

1.3.1 NJDOT-OMR Dredge Pilot Hydrodynamic Study

The **NJDOT-OMR** Dredge Pilot Hydrodynamic Study proposed by Robert Chant, Rutgers University and Tim Wilson, USGS, which will mainly cover areas down-estuary of the Harrison Reach (approximately river mile (RM) 4.4), will meet their study objectives through the following work:

- Installation of long-term moorings in the Passaic River and shipboard surveys to characterize the salinity and sediment structure of the River over a range of river flow conditions. The fixed stations are expected to remain in place for a year from approximately June 2004 through June 2005. The discrete sample monitoring is expected to occur from June 2004 through June 2005.
- Detailed tidal cycle surveys in the Harrison Reach to characterize the spatial structure of currents, total suspended sediment, stratification and bottom shear stress in the vicinity of the pilot dredging study
- A dye study to quantify the dispersive nature of material released into the water column in the Harrison Reach of the river.

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[1] Several of the important contaminants of potential concern (COPCs) in the Lower Passaic River (*e.g.*, dioxin, polychlorinated biphenyls (PCBs), mercury) are associated with particles. Various processes affect the total suspended sediment (TSS) concentrations in estuaries in time scales that vary from seconds to

1.3.2 Superfund Study

The Superfund monitoring program will cover all five reaches that encompass the 17-mile tidal portion of the Lower Passaic River and will not duplicate the sampling conducted for NJDOT-OMR. The Superfund team's surveys and discrete sampling are expected to start in November 2004 and, to the extent possible, the NJDOT-OMR and Malcolm Pirnie sampling efforts will complement each other. The activities that will be implemented to achieve the Superfund program objectives are listed in Section 2 below.

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years. These processes include, but are not limited to, turbulence, tidal circulation, wind waves, freshwater discharge, and climate.

Section 2
Detailed Sampling Tasks and Procedures

2.1 Sampling Activities

During the Superfund hydrodynamic and sediment transport monitoring program, the following sampling activities will be conducted:

- Moored instrumentation will be installed at fixed stations within each reach of the river to monitor turbidity, temperature, velocity, depth, conductivity. This activity will be required for Objectives 1 and 6.
- Shipboard and cross-sectional surveys will be conducted to monitor turbidity, temperature, velocity, depth, and conductivity, as well as to collect water samples for TSS, VSS, POC, beryllium-7 (Be-7) and thorium-234 (Th-234) analyses at different river flows, precipitation events and tidal ranges. This activity will be required for Objectives 1, 5 and 6. Note that studies in estuarine systems (Ciffroy et al., 2003; Feng et al. 1999a, 1999b) have suggested that naturally-occurring radionuclides that associate strongly with particles (*e.g.* Be-7 and Th-234) are useful tracers of the processes affecting particle dynamics within estuaries. A description of the use of these naturally-occurring radionuclides as particle tracers can be found in Appendix A.
- A gauging station will be installed above the Dundee Dam to monitor river discharge and collect samples for water quality analyses including: TSS/volatile suspended solid (VSS), POC, grain size, Be-7 and Th-234. This activity will be required for Objectives 3 and 5.
- Surface sediment samples will be collected for Be-7 and Th-234 analyses. This activity will be required for Objective 5.
- Special sediment characterization studies will be performed to characterize erosion and settling/flocculation. This activity will be required for Objective 2.
- A bathymetric survey will be conducted for the entire 17-mile stretch. This activity will be required for Objective 4.

A detailed description of the field work and sampling activities are presented below. The Standard Operating Procedures (SOPs) that are applicable to the field work are provided with the other project SOPs as an Attachment to FSP Volume 1. Note that the grain size analysis mentioned in this monitoring plan refers to a rapid particle classification as cohesive (less than 62.5 μm) and non-cohesive (greater than 62.5 μm) fractions. The number of samples and analyses for each activity described below are summarized in Table 1.

2.2 Surface Water Monitoring At Moored Stations

The continuous monitoring using moored instrumentation installed at fixed stations within each reach of the Lower Passaic River, which will result in fixed-point time series of a variety of model calibration and evaluation data, including current velocities and directions, salinity, temperature and suspended sediment concentrations will be required to meet parts of objectives 1 and 6 given in Section 1.2. The activities of **NJDOT-OMR** and the Superfund team needed to achieve to conduct surface water monitoring at moored stations are summarized below.

2.2.1 NJDOT-OMR Activities

Based on the Rutgers/USGS final proposal (2004), **NJDOT-OMR** will install an array of six moorings (Figure 1). Two of these moorings will be deployed in the Harrison reach, one located in the deep channel, and the second on the shoaling southern flank. Each of these two moorings will contain an Acoustic Doppler Current Profiler (ADCP), surface and bottom conductivity/temperature (CT) sensors, and a bottom optical backscatter sensor (OBS). The other four moorings will contain surface- and bottom-mounted CT sensors. In addition, the farthest upstream and downstream moorings will each contain OBS sensors and paroscientific pressure sensors that are accurate to a few millimeters. The pressure sensors will provide estimates of along-river pressure gradients that, together with time-series of velocity measurements from the central array, can be used to provide bulk estimates of bottom shear stress, which will be useful for modeling efforts. The ADCPs will obtain estimates of current velocity in 25 cm bins at a temporal resolution of 15-30 minutes. The ADCP also records the acoustic backscatter that can be calibrated against the measured suspended sediment from bottle samples to provide high-resolution estimates of total suspended sediment.

NJDOT-OMR proposes two mooring deployments. The first is expected to run from late summer to late fall to capture both circulation during the low flow summer conditions and the increased river discharge rates that occur in the fall. The second deployment will cover the late winter/early spring to catch the spring freshet. In conjunction with these moorings, NJDOT-OMR plans to collect a single vertical profile of suspended sediment, total dissolved salt, conductivity, and water density in the vicinity of each mooring - once when the moorings are deployed and again when retrieved. As per the request of the Superfund team, the NJDOT-OMR TSS samples will also be analyzed for VSS. Up to 10 samples will be collected at 1 meter intervals. The data provided by these samples will document the calibration of the instrumentation. The maximum total number of samples collected for the mooring work is estimated at 240.

2.2.2 Superfund Team Activities

The **NJDOT-OMR** mooring installations end in the Newark Reach. Since information on hydrodynamics and sediment transport in the entire 17-mile tidal system is needed, the Superfund team will install 3 moorings in the following up-estuary areas: 1) one station between the Dundee Dam and the Third River; 2) one station between the Third River and the Second River, and; 3) one station in the Kearny Reach (see Figure 1). The Superfund team also expects that a fourth monitoring station will be installed in Newark Bay by Tierra Solutions, Inc. (TSI). The Superfund mooring stations will contain: (i) a surface and a bottom OBS unit that monitors turbidity (ii) surface and bottom CT sensors, with the surface sensors approximately 1 meter below water surface and the bottom sensors approximately 1 meter above the sediment (Kearny Reach and Newark Bay stations only); and (iii) an ADCP that monitors the water column current profile for all stations. During the deployment and retrieval of these moorings, the Superfund team will collect a single vertical profile of 10 1-Liter bottle samples at approximately 1 meter intervals, in the vicinity of each mooring. The total expected number of samples is 60 and each will be analyzed for TSS, VSS, and conductivity.

2.3 Discrete Surface Water Sampling During CTD Shipboard Surveys

Data will be collected during shipboard surveys to supplement the data obtained from the moorings, as well as to:

- Characterize the strength of the two-layer flow in the tidal Passaic River
- Delineate the location of the salt wedge and the stratification as a function of river flow
- Identify the physical and chemical processes affecting the short-term particle transport and deposition
- Provide data to test the skill of the planned hydrodynamic model simulation of the Lower Passaic River

The activities of NJDOT-OMR and the Superfund team during the CTD surveys are summarized below.

2.3.1 NJDOT-OMR Activities

From June 2004 through June 2005, NJDOT-OMR will run approximately 12 CTD surveys beginning in Newark Bay and ending either at the head of salt or as far as the river is navigable. NJDOT-OMR will attempt to procure a low-clearance vessel so that, combined with operating at low tide, navigation will be possible in the upper reaches of the Lower River where bridge clearance can be less than 8 feet. They will select dates that cover a range of river discharges with emphasis on high-discharge conditions. Salinity will be measured with an OS-200 CTD probe that obtains estimates of salinity, temperature and pressure at a rate of 6 Hz. CTD casts will be made at approximately 1-km intervals in the river. The CTD will be mated with an OBS to characterize the suspended sediment concentration. Within each CTD section, approximately 10 1-liter bottle samples will be collected to calibrate the OBS sensor. In addition, NJDOT-OMR will sample the river water to determine the suspended sediment and salinity distribution in detail. At approximately 1-km intervals, one vertical profile will be sampled at four depths to characterize the particulate and salt distribution across the river. Samples will be collected at 1 meter below the surface, 1 meter above the bottom, and at 2 locations through the mid-range depth. The mid-river vertical profile will be made in the vicinity of the CTD tow, allowing the data to be used for instrument calibration as well as river characterization. Samples will be measured for suspended sediment, total dissolved salts, and conductivity. The total number of sampling locations for this objective is 960. A subsection of these samples will also be measured for density in the USGS District Laboratory.

The Superfund team has requested that NJDOT-OMR collect water samples during the CTD surveys for POC and grain size analysis. It is assumed that POC samples will be collected during the first two CTD surveys (approximately 50 samples), while grain size will be collected under different discharge conditions during any two CTD surveys (approximately 40 samples). The POC and grain size samples will be analyzed by the Superfund team. The TSS samples collected by NJDOT-OMR will also be analyzed for VSS by the USEPA Edison Lab.

2.3.2 Superfund Team Activities

The Superfund team will be involved in three separate activities including: (i) extending the CTD surveys up-estuary of the NJDOT-OMR CTD survey, (ii) collecting suspended particulates samples for radionuclides analysis along the longitudinal axis of the estuary and, (iii) collecting suspended particulate samples for radionuclides analysis at the ETM.

It is assumed that that the NJDOT-OMR CTD survey will likely end at approximately River Mile (RM) 12 because of a low bridge in this vicinity. To provide complete characterization of the 17-mile Lower River, the Superfund team will complement the NJDOT-OMR CTD surveys by conducting approximately 10 CTD surveys and collecting vertical profiles of water samples at approximately 1-mile intervals starting at Ackerman

Bridge (approximately RM 16) and ending at RM 12. The Superfund team will collect water samples at 1 meter below the surface and 1 meter above the bottom at four stations per cross-section for TSS/VSS and conductivity analyses (80 samples). Approximately 16 water samples will be collected for grain size analysis.

During three of the CTD surveys, the Superfund team will collect large suspended particle samples in the vicinity of each mooring for radionuclide (Be-7 and Th-234) analysis. The samples will be collected by filtering large-volume water samples (from 200 to 1500 L, depending on location) using protocols described in Feng *et al.* (1999a) and summarized in Appendix B. Samples will be collected at two depth intervals: surface (approximately 1 meter below surface) and near-bottom (approximately 1 meter above bottom) using a boat-powered pumping system. The pumped water will be filtered to obtain approximately 5 to 15 grams of suspended sediment for analysis. Since this process may require up to two hours, the Superfund team will also collect separate aliquots of 500-ml water samples at the beginning and at the end of pumping at each station for TSS and conductivity analysis. These 500-mL samples will provide information on the changes in the water column properties during the pumping process. The analysis of this data will be in accordance with Feng *at al.* (1999b). The total number of suspended particulate samples for radionuclide analyses is expected to be 48; 96 water samples will be collected for TSS and conductivity analyses.

In an effort to understand the dynamics and sources of particles to the ETM, the Superfund team will also set up a cross-section of three stations in the ETM and collect large-volume water samples for analysis of suspended particle radionuclides (Be-7 and Th-234). Sampling will be conducted over the course of several tidal cycles in the ETM, with the three stations being sampled on three successive days (1 station per day). The suspended particles will be collected approximately 6 to 8 times per day, at two depth intervals: surface (approximately 1 meter below the surface) and near bottom (approximately 1 meter above the bottom). Protocols for collecting these samples are provided in Appendix B. The analysis of this data will be performed in accordance with

Feng *at al.* (1999b). The maximum number of samples to be collected for radionuclide analysis is 48; 96 water samples will be collected for TSS and conductivity.

2.4 Discrete Surface Water Sampling During Cross-Section Ship-Track Surveys

Most of the activities above focus on sampling along the main channel, with little consideration to cross-sectional variability. Cross-sectional surveys and sampling are important as they provide information on cross-channel circulation, especially along river bends. They also provide water quality cross-sectional distribution data that will be useful in assessing the model's capability to simulate observed vertical and cross-channel shears in the flow. Assessment of the model's capability to adequately simulate vertical and cross-channel shears in flow is critical since vertical and horizontal shears drive dispersion in a tidal riverine system (Rutgers/USGS Proposal, 2004; Taylor, 1951; Wilson and Okubo, 1975; Smith, 1976; Fischer, 1978). Cross-sectional ship track survey activities by NJDOT-OMR and the Superfund team are outlined below.

2.4.1 NJDOT-OMR Activities

NJDOT-OMR proposes a total of four days of shipboard surveys to characterize the tidal currents. This field work will occur in the late summer/early fall of 2004, with two of the shipboard surveys conducted during neap tide conditions and two surveys conducted during spring tide conditions. NJDOT-OMR will complete the sections shown in Figure 2 approximately once every hour over an 8-12 hour period. By fitting tidal period harmonics to time series of currents observed at grids along this track NJDOT-OMR will generate a detailed model of tidal currents in this reach during neap tide and spring tide conditions. NJDOT-OMR anticipates spending approximately 3 minutes surveying each 100-meter section to generate currents with resolution of approximately 10 meters in the cross-stream direction and 25-cm in the vertical. This would provide a more spatially detailed view of the tidal and subtidal motion in the Harrison Reach than provided by the moorings. In conjunction with these cross-sectional tidal current surveys NJDOT-OMR proposes to also characterize the cross sectional distribution of suspended sediment and dissolved salt in this reach of the river. During the shipboard surveys, samples will be collected at each cross section in a grid of three verticals at three depths (1 meter below surface, one meter above bottom, and mid section, 9 samples total per cross section). These samples will be analyzed for suspended sediment, dissolved salt, and conductivity. Approximately 470 samples will be collected.

During one of the shipboard surveys, the Superfund team has requested that NJDOT-OMR collect water samples for grain size (18 samples) along one cross-section in the Point No Point Reach and one cross-section along the Harrison Reach. Because the NJDOT-OMR TSS analysis will be done by the EPA Edison Lab, the Superfund Team has also requested that the TSS samples be analyzed for VSS.

2.4.2 Superfund Team Activities

Due to the limited extent of the NJDOT-OMR cross-section survey, the Superfund team will expand the cross-section surveys to areas up-estuary of the Harrison Reach. On two days during neap tides and two days during spring tides the Superfund team will conduct ship board surveys starting from approximately RM 5 up to the Ackerman Bridge, monitoring currents using an ADCP and collecting water samples along river sections spaced approximately 1 mile apart (~ 12 cross-sections). At each cross-section, the Superfund team will: (i) use an ADCP to generate currents with resolution of approximately 10 meters in the cross-stream direction and 25-cm in the vertical, and (ii) collect water on a grid of three verticals at two depths (1 meter below surface and 1 meter above bottom) for TSS/VSS, and conductivity analysis (264 samples).

During one of the shipboard surveys, the Superfund team will collect additional water samples for grain size analysis along one cross-section in the Newark Reach, one cross-section in the Kearny Reach and two cross-sections in the Upstream Reach. Each cross-section will consist of a grid of three verticals at two depths (1 meter below surface and 1 meter above bottom) for a total 24 samples.

2.5 Monitoring Gauge and Water Quality at Dundee Dam

It is important to accurately quantify the flux of contaminants over Dundee Dam because Dundee Dam is a boundary condition for the proposed Superfund hydrodynamic and sediment transport model for Passaic River. The Superfund team and the EPA will work with the USGS to set up a gauging station just above the dam, to quantify the discharge over the dam. In addition, this station will be used to collect surface water samples, under varying flow conditions, for TSS, VSS, grain size and POC analyses. The details of this monitoring are yet to be finalized.

2.6 Surface Sediment Sampling

Collection of surficial sediment samples will be conducted by the Superfund Team only. To compare the radionuclide activities in the water column relative to that in surface sediments, surface sediments samples (0 to 0.5 cm) will be collected using a box corer by the Superfund field team in the vicinity of the moorings where water samples are collected for the radionuclide analysis (approximately 9 samples), as well as along the cross section of the ETM (approximately 3 samples). The sediments will be analyzed for Be-7 and Th-234 along with grain size.

2.7 Special Sediment Studies

The sediment transport model that will be developed for the site (Refer to Section 7) will include sediment erosion, sediment transport, and deposition of both cohesive and non-cohesive sediments. Calibration of these processes requires that data be collected to determine site specific values of parameters in the formulations describing these processes. The primary site characteristics that affect sediment stability are the shear stress at the river bottom under varying conditions and the physical properties of the upper sediment layers, which can be affected by bioturbation.

Sediment deposits can change significantly in spatial extent (both horizontally and vertically) and can be resuspended and redeposited by storms and other river hydraulic altering events (e.g., dredging). For the long-term prediction of both sediment and contaminant transport, one of the most significant processes to understand and quantify is sediment erosion. These rates can change by orders of magnitude, not only as a function of the applied shear stress due to waves and currents but also as a function of horizontal location and depth in the sediment. In this hydrodynamic and sediment transport special sediment studies will be conducted for sediment erosion, and sediment settling/flocculation as descried below.

2.7.1 Sediment Erosion

Cohesive sediment erosion is highly site-specific, requiring site specific measurements to parameterize model formulation for erosion. Erosion rates depend on the relative magnitude of the shear strength of the sediment and the shear stress exerted on the sediment surface. The shear strength can be affected by the following parameters: bulk density, particle size, mineralogy, organic content, salinity of the pore water, amount of gas, oxidation or other chemical reactions, and consolidation time. Erosion measurements involve specialized devices, and two devices will be used to characterize the erodability of sediments in Passaic River, including the Gust Microcosm to understand erosion at the surface and SedFlume to understand erosion with depth. The erodability experiments will be conducted in the field on relatively undisturbed cores collected from at least 15 locations in the river. Sediment cores will be collected using box corers for these experiments. After each core is collected, a Density Profiler (Gotthard, 1998) will be used to give a non-destructive and high resolution measurement of bulk density as a function of depth in the core. In addition, sediment samples will be obtained for Pb-210 analysis over 15 depths in the top 40-50 cm of the sediment cores. During the erosion test, small amounts of sediment will be removed at different depths in the core and used to determine the other bulk properties of the sediment sample including water content, grain size (using a Malvern Mastersizer) and organic content (Roberts et al., 1998).

2.7.1.1 Gust Microcosm

For the surface sediments, Gust Microcosm field experiments will be conducted to test for changes in surficial sediment erodibility over the range of 0-0.4 Pa applied shear stress. These erosion tests and protocols, which involve increasing shear stress through approximately 8 levels, with each level of constant stress lasting approximately 20 minutes, are described in detail in Sanford and Maa (2001). This experiment will only be conducted on a subset of samples.

2.7.1.2 SedFlume

SedFlume experiments will be conducted on sediment cores to determine erosion rates as a function of depth and shear stress. This flume can measure erosion rates of sediments at high shear stresses (up to stresses on the order of 20 N/m2) and with depth (down to a meter or more). Therefore, Sedflume measures in-situ sediment erosion at shear stresses ranging from normal flow to flood conditions and with depth below the sediment/water interface. Protocols for conducting SedFlume experiments are described in McNeil, et al. (1996) and the SedFlume theory is summarized in Appendix B.

2.7.2 Sediment Settling/Flocculation

Settling is the downward movement of sediments through the water column due to gravity. In the case of cohesive sediments, flocs are formed by the process of flocculation, which is the result of simultaneously occurring aggregation and floc break-up processes. A combination of in-situ techniques are being considered to determine settling velocities of particles in the Passaic River. First option is to conduct Modified Valeport Settling Tube experiments (Owen-type bottom withdrawal settling tube) on water column TSS samples to determine settling velocities. This instrument consists of a long slender tube, which is lowered in the water in horizontal position to collect a water column sample. The protocols for determining the settling velocity using this tube are described in Sanford, et al. (2001). The second in-situ method includes the use of a laser in situ scattering and transmissometry (LISST) instrument system in combination with an optical backscatter sensor (OBS). These devices have been used to determine concentration and fall velocities of estuarine particle populations in the lower Chesapeake Bay, and the details are described in Fugate and Friedrichs (2002). The third method of in-situ measurement involves the use of a video settling tube that optically monitors the settling flocs in a vertical tube. This system is generally used in the Lagrangian mode, and suspended flocs are captured in a so-called capture/stilling chamber. Digital image analysis techniques have been developed to establish floc size and settling velocity distribution, and sometimes floc structure from the video recordings and the protocols are described in Eisma, (1996) and Dyer et al. (1996).

2.8 Bathymetric Survey of River Bottom

The Superfund Team will conduct a bathymetric survey of the entire 17-mile stretch of the study area. This data will provide addition information to the modelers on sediment stability, and can be compared to historical surveys done at this site. The bathymetric survey will be conducted using a survey vessel and an Innerspace 455, 200 KHz single-beam survey grade fathometer for this work. The bathymetry shall be referenced to NGVD 29. The survey will be conducted using 100-foot lanes and its accuracy will be greater than or equal to +/- 0.5 feet. Approximately eight vertical controls will be established over the length of the river to complete the survey.

There are 20 bridges that cross the Passaic over the 17 mile survey area. There will be GPS multi-path errors, possibly at every bridge. As much as 500-1000 feet of coverage could be lost on each side of these bridges. This will be corrected by the use of Total Station. Following the completion of the survey work, the data will be reviewed and a determination will be made about multi-path errors around each bridge. A secondary survey will then be conducted using a Total Station setup to recollect data in those areas.

The survey team will use a Trimble real time kinematic (RTK) GPS capable of repeatable centimeter accuracy for navigation control and positioning while conducting the survey. Positioning data will be collected in NJ State Plan NAD 83 and sent to a computer running Coastal Oceanographics Hypack Max software for survey control, ship positioning, and data acquisition. Positioning data will be collected every second while conducting surveys. Survey lines will run perpendicular to the riverbank.

The Superfund team will coordinate this effort with a USACE bathymetric survey on the navigable portion of the river that is expected to occur in summer 2004.

Table 1. Summary of Number of Samples and Analysis per Sampling Activity for Superfund Team and NJDOT-OMR Team

Activity	Superfund Team		NJDOT-OMR Team	
	Total # Samples	**Analysis (# Samples)**	**Total # Samples**	**Analysis (# Samples)**
Moorings	60	TSS,VSS, Conductivity (60 samples)	240	TSS,VSS[3], Conductivity, water density
CTD Surveys	396	TSS,VSS[2], Conductivity (272 samples)	1010	TSS,VSS[3], Conductivity (960 samples)
		Grain Size (16 samples)		[1]POC (50 samples)
		Be-7 & Th-243 (108 samples)		[1]Grain Size (40 samples)
Shipboard Surveys	288	TSS,VSS, conductivity (264 samples)	488	TSS,VSS[3], conductivity (470 samples)
		Grain Size (24 samples)		[1]Grain Size (18 samples)
Surface Sediment	12	Be-7 & Th-243, Grain size (12 samples)		

[1] Samples collected by NJDOT-OMR for Superfund Team
[2] VSS analysis performed on 80 of the 272 samples only
[3] VSS analysis of water samples will be done as per Superfund Team request.

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APPENDIX A

Naturally-Occurring Radionuclides as Particle Tracers

Naturally-Occurring Radionuclides as Particle Tracers

One of the objectives of the Superfund monitoring program is the determination of the processes controlling the short-term particle dynamics within the estuary, especially in the region of the ETM. Studies done by Feng *et al*. (1999a, b) and Ciffroy *et al*. (2003) suggest that naturally occurring radionuclides can be used as tracers to understand the processes affecting particles dynamics in estuarine environments since the source terms and the rate of radioactive decay for these radionuclides are well known. Be-7 (half-life = 53 days) and Th-234 (half-life = 24 days), which have strong affinity for particle surfaces, were found useful in discerning short-term variations in the Hudson River Estuarine system. Th-234 is produced from Uranium-238 decay and a distribution coefficient (K_D) reported in the technical literature is summarized by Feng *et al*. (1999a) to be from 10^5 to 10^6. Th-234 production varies with salinity and Feng *et al*. (1999a) observed that if all other factors are equal, particles that scavenge Th-234 from higher salinity portion of the Hudson River estuary have higher excess Th-234 activities relative to those that are exposed to lower salinity water. Beryllium-7 (K_D approximately 10^5); however, is produced in the atmosphere by cosmic-ray spallation of nitrogen and oxygen, and atmospheric deposition is the main source to the estuary (Feng *et al*. 1999a). The different source functions of Th-234 and Be-7, along with their strong particle affinity and short half-lives, make them suitable for understanding the transport and fate of particles associated with contaminants in an estuarine system.

A distinctive feature of estuaries is the turbidity maximum zone, which is a region where the concentration of TSS may be a hundred times greater than concentrations both seaward and landward. There are several mechanisms responsible for the formation and maintenance of this region. Feng *et al*. (1999a, b) and Ciffroy *et al*. (2003) used natural radionuclides (Be-7 and Th-234) as tracers to understand the relative importance of local resuspension and lateral advection as sources to the ETM during the course of a tidal cycle, as well as the residence time of solids in the ETM (*e.g.*, Feng *et. al*., 1999a,b; Ciffroy *et. al*., 2003).

APPENDIX B
SEDFLUME THEORY

SedFlume Theory

Sedflume (McNeil, et al. 1996) is a straight flume that has a test section with an open bottom through which a circular cross-section coring tube containing sediment can be inserted (see Figure below). The main components of the flume are the coring tube; the test section; an inlet section for uniform, fully developed, turbulent flow; a flow exit section; a water storage tank; and a pump to force water through the system. The coring tube, test section, inlet section, and exit section are made of clear acrylic or polycarbonate so that the sediment-water interactions can be observed. The coring tubes are generally 50-60 cm long and have a 10 cm diameter round cross section. For these experiments, the coring tube will penetrate only 20-25 cm into the sediment bed.

Water is pumped directly from the water source (in this case, Newark Harbor or Passaic River), through a 5 cm diameter flexible hose, to the flow converter and then into the rectangular duct. The duct is 2.5 cm in height, 10 cm in width, and 120 cm in length; it connects to the 15 cm long test section. The flow converter changes the shape of the flow cross-section from circular to the rectangular duct shape while maintaining a constant cross-sectional area. A three-way valve regulates the flow so that part of the flow goes into the duct while the remainder returns to the water source. In addition, there is a small valve in the duct immediately downstream from the test section that is opened at higher flow rates to keep the pressure in the duct and over the test section at atmospheric conditions.

At the start of each test, the coring tube filled with sediment relatively undisturbed sediments extracted from the sediment bed. The sediment-filled coring tube is inserted into the bottom of the test section. An operator moves the sediment upward using the plunger, which is inside the coring tube and is connected to a jack. The jack is driven by motor, which is regulated with a switch. By this means, the sediment surface is raised and made level with the bottom of the test and inlet sections. The speed of the jack movement can be controlled at a variable rate in measurable increments as small as 0.5 mm.

Water is forced through the duct and the test section over the surface of the sediments. The shear produced by this flow, if great enough, causes the sediments to erode. As the sediments in the core erode, the core surface is moved upwards by the operator as necessary so that the sediment-water interface remains level with the bottom of the test and inlet sections. The erosion rate is recorded as the upward movement of the sediments in the coring tube over time. Duration of each erosion test for a specified shear stress is dependent on the rate of erosion and generally is between 0.5 and 10 minutes. After the initial test is performed at low shear stress, the operator increases flow to a specified higher rate and again records erosion results. This is continued until erosion is significant, at which point the flowrate is decreased to the initial value and the series of erosion experiments with increasing stress is performed again. This method provides data on erosion rate for specified shear stresses and their variation with depth. In addition, samples are collected from the core at pre-determined depths to collect depth-variable bulk property data.

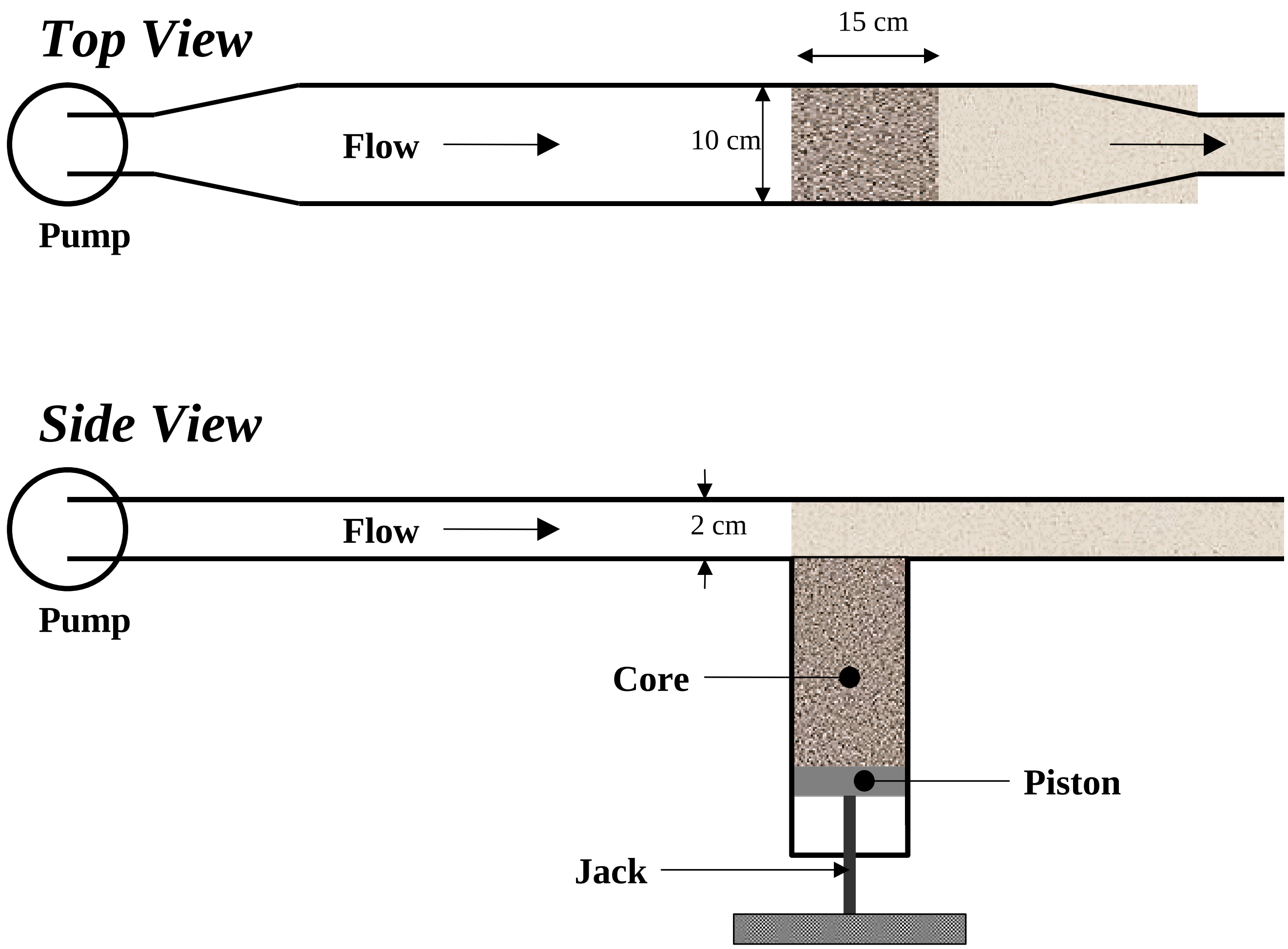

Figure 1: SedFlume Configuration